

Strategic Plan for VLBNO at Homestake

**Presented to
Homestake Workshop**

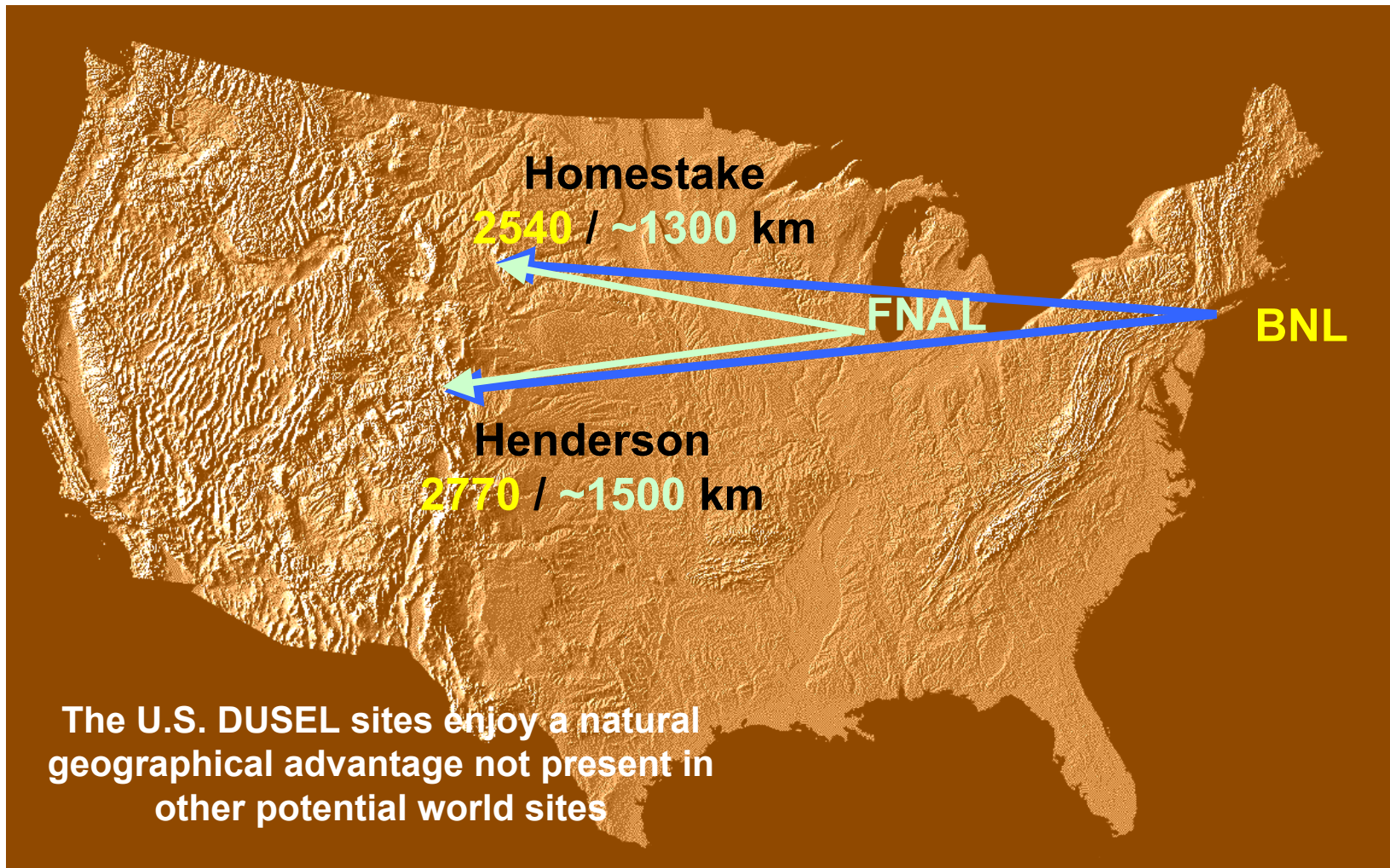
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**Lead, S. Dakota
February 9, 2006**

Summary Case for VLBNO in DUSEL

- All parameters of neutrino oscillations can be measured in one experiment
 - every one of the oscillation parameters is important to particle physics
 - the oscillation parameters contribute to important cosmology questions
 - a ν_e **appearance** experiment is required to determine all the parameters
 - a **broadband Super Neutrino Beam** at very long distances combined with the ability to identify **quasi-elastic neutrino scattering** in the detector is key
 - the **Very Long Baseline Neutrino Oscillation (VLBNO)** Exp. is the best method
- The massive VLBNO detector can provide additional forefront physics
 - a powerful next-generation **Nucleon Decay** search
 - supernova, atmospheric and geo-neutrino neutrino investigations
 - a deep underground detector in the prospective **NSF DUSEL** is ideal for VLBNO
- The CP-violation parameter δ_{CP} is the most difficult number to determine
 - matter effects interact with CP-violation effects to produce intrinsic ambiguities
 - the CP-violation phase δ_{CP} has distinct effects over the full 360° range
 - **systematic errors are minimized** using a **single detector** in a **broadband beam**
 - the VLBNO detector can be staged in ~100KT modules as the program develops
 - antineutrino running offers a complementary way to demonstrate CP-violation and may be pursued at a later stage of VLBNO if demanded by the physics

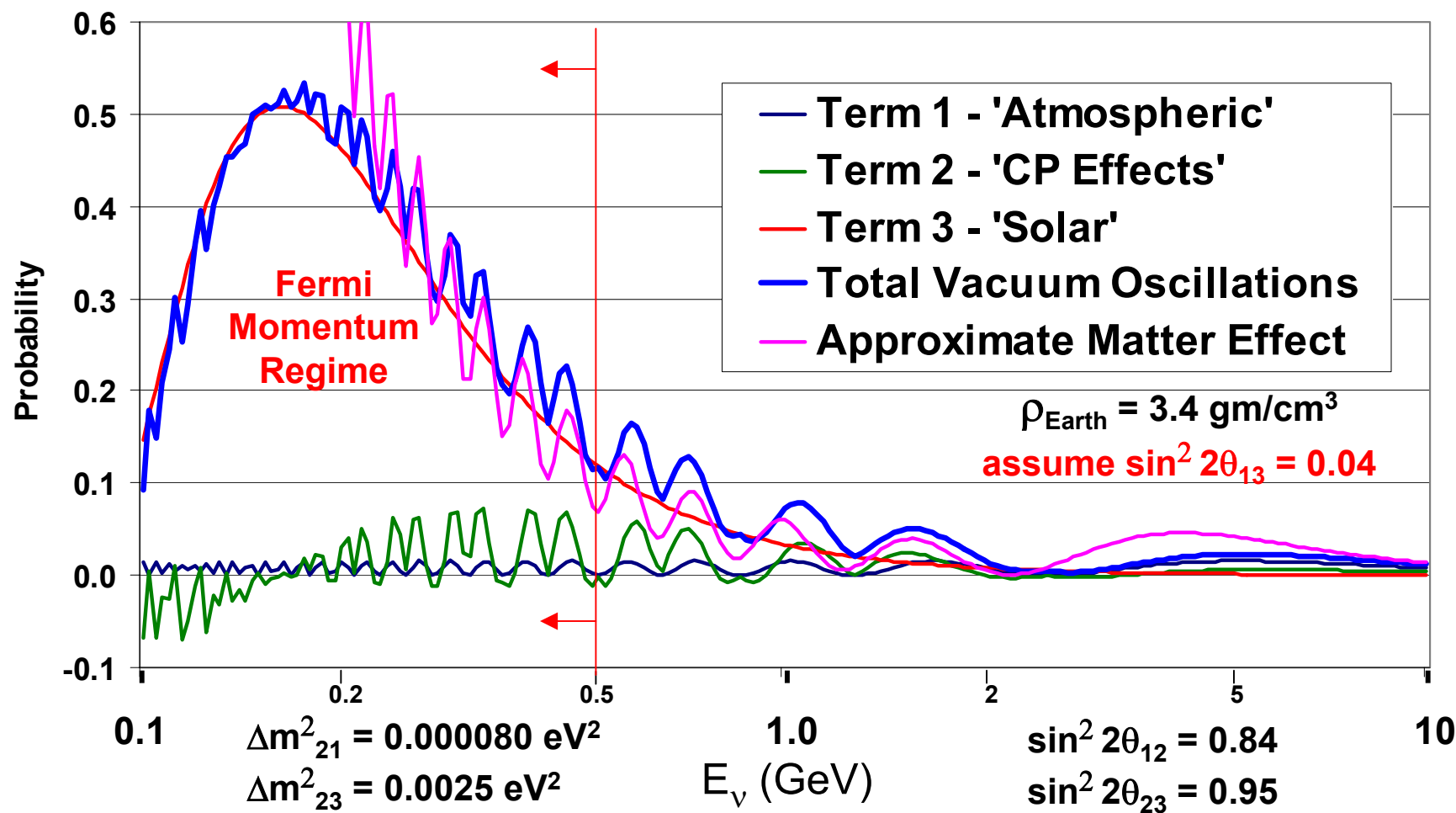
Super Neutrino Beam to DUSEL Candidate Sites



Electron Neutrino Appearance by Oscillation in Vacuum

$\nu_\mu \rightarrow \nu_e$ Vacuum Oscillations - VLBNO

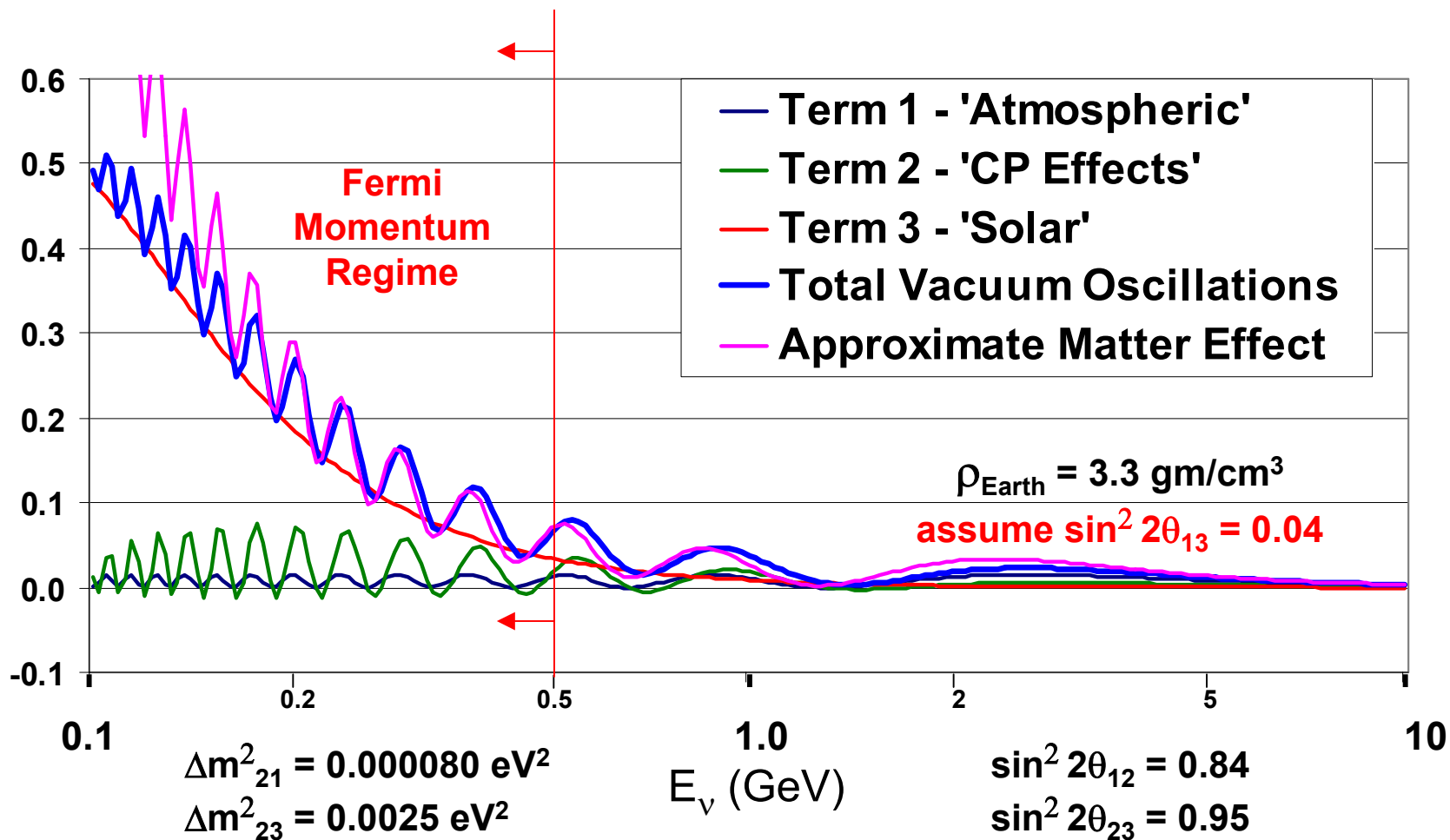
$L = 2540$ km – BNL to **Homestake**



Electron Neutrino Appearance by Oscillation in Vacuum

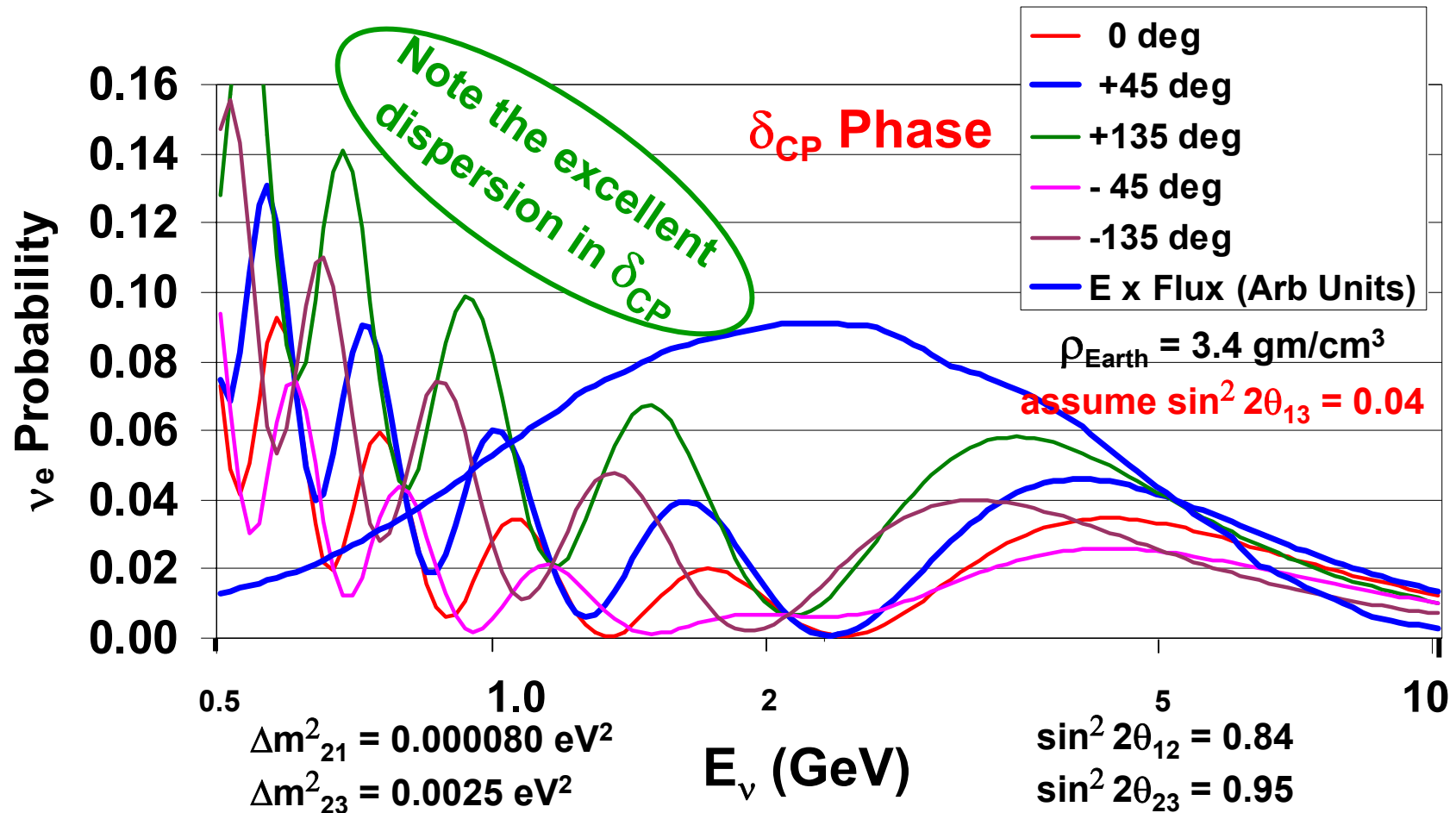
$\nu_\mu \rightarrow \nu_e$ Vacuum Oscill. - VLBNO

$L = 1300$ km – FNAL to **Homestake**



Electron Neutrino Appearance – CP Phase Sensitivity

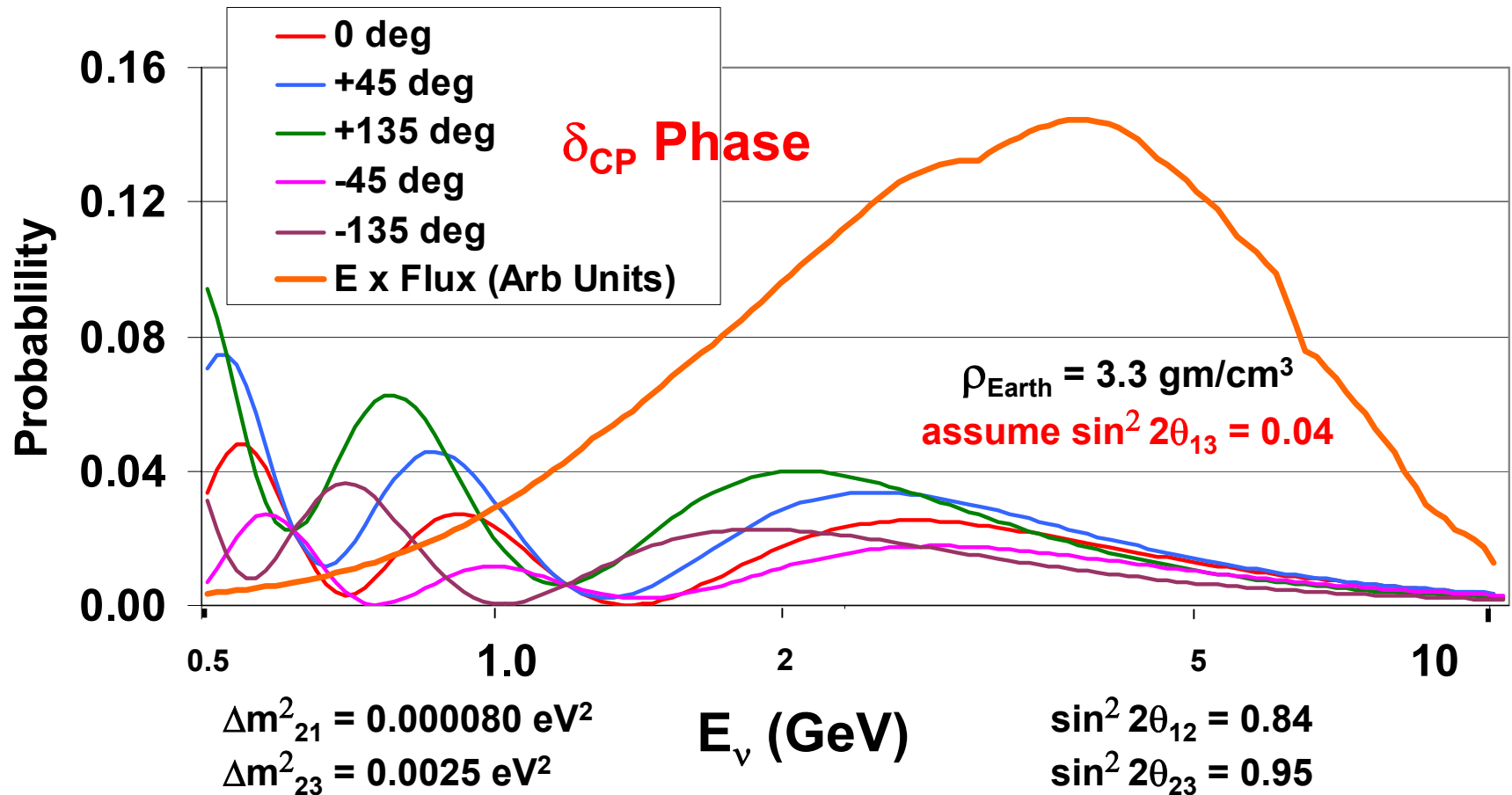
$\nu_\mu \rightarrow \nu_e$ CP Phase Effects - VLBNO
L = 2540 km – BNL to **Homestake**



Electron Neutrino Appearance – CP Phase Sensitivity

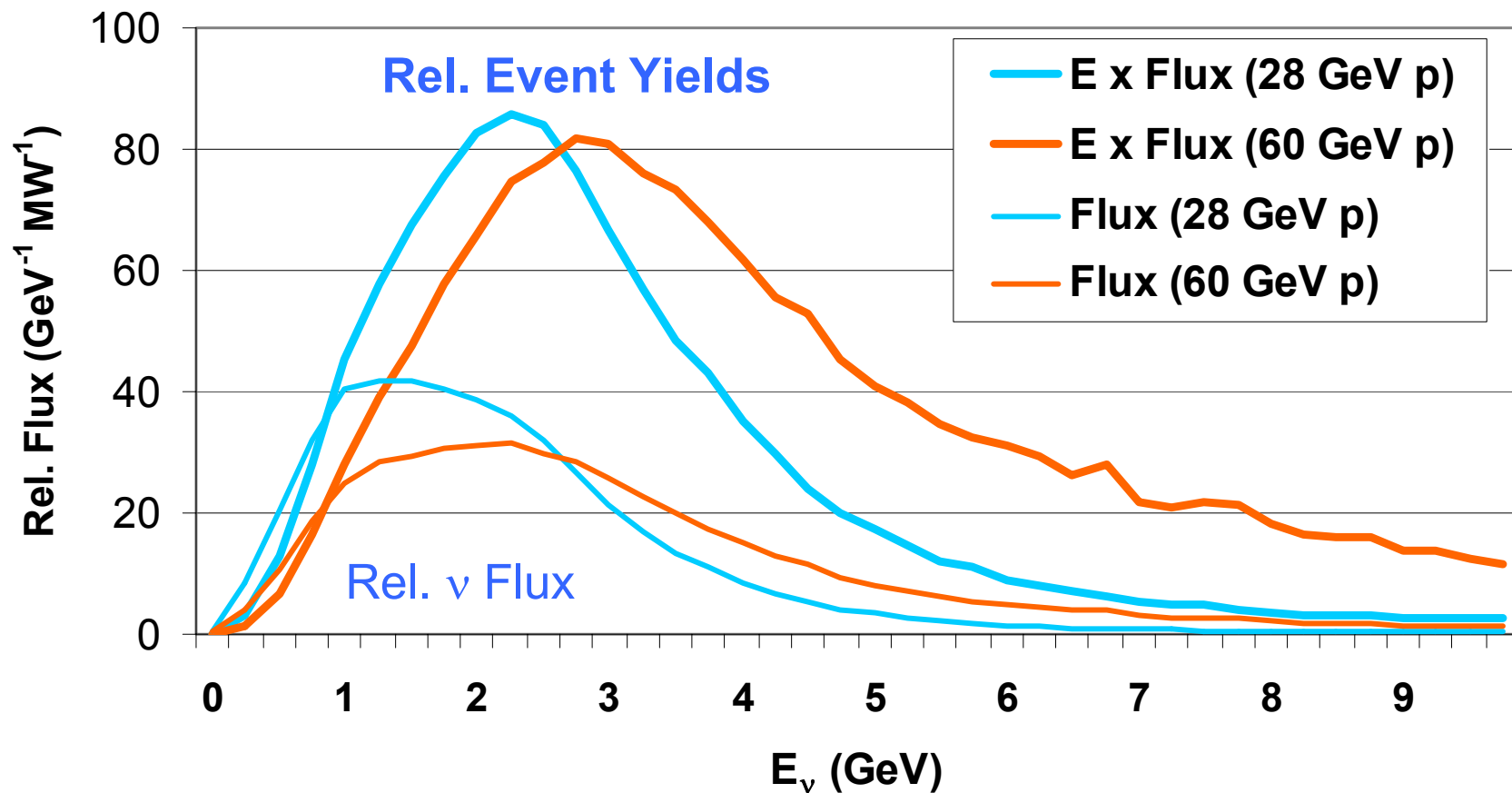
$\nu_\mu \rightarrow \nu_e$ CP Phase Effects - VLBNO

L = 1300 km – FNAL to **Homestake**



A Word About Primary Proton Beam Energy

ν_μ Flux vs E_ν at Constant Target Power PBEAM Flux Program + BNL Wideband Horn



Strategy for a VLBNO Program at DUSEL

Educate and promulgate the *VLBNO method* in the HEP community

- the power of a single beam and a single detector is gradually being appreciated
- the ability to *distinguish quasi-elastic events from background* is now in place (the pattern recognition work of Chiaki Yanigasawa is critical to this point)
- the magnitude of $\sin^2(2\theta_{13})$ will be bounded or measured in the next few years by T2K plus reactor experiments, showing whether CP-violation can be measured by any super neutrino beam experiment, ie., $\theta_{13} > \sim 2\text{-}3$ degrees
- even if $\sin^2(2\theta_{13}) < 0.01$, the VLBNO experiment remains the most cost-effective way to measure the other neutrino oscillation parameters to good precision
- the narrow-band, off-axis method requires multiple detectors plus long antineutrino running to achieve a complete measurement of all the oscillation parameters to determine δ_{CP} *without ambiguities* (requires $\theta_{13} > \sim 2\text{-}3$ degrees)

Promote a *Super Neutrino Beam* source from BNL *or* Fermilab

- DUSEL site candidates presently include both Homestake and Henderson
- in consequence, the very long baselines needed by VLBNO could be realized from BNL *or* Fermilab
- Europe and Japan are not geographically positioned to perform a VLBNO exp. (Japanese physicists are now thinking about a beam to Korea from Tokai)
- the U.S. particle physics program wins with either BNL or Fermilab as a source

Strategy for a VLBNO Program at DUSEL (Cont.)

Organize to produce the necessary strategy and design documents

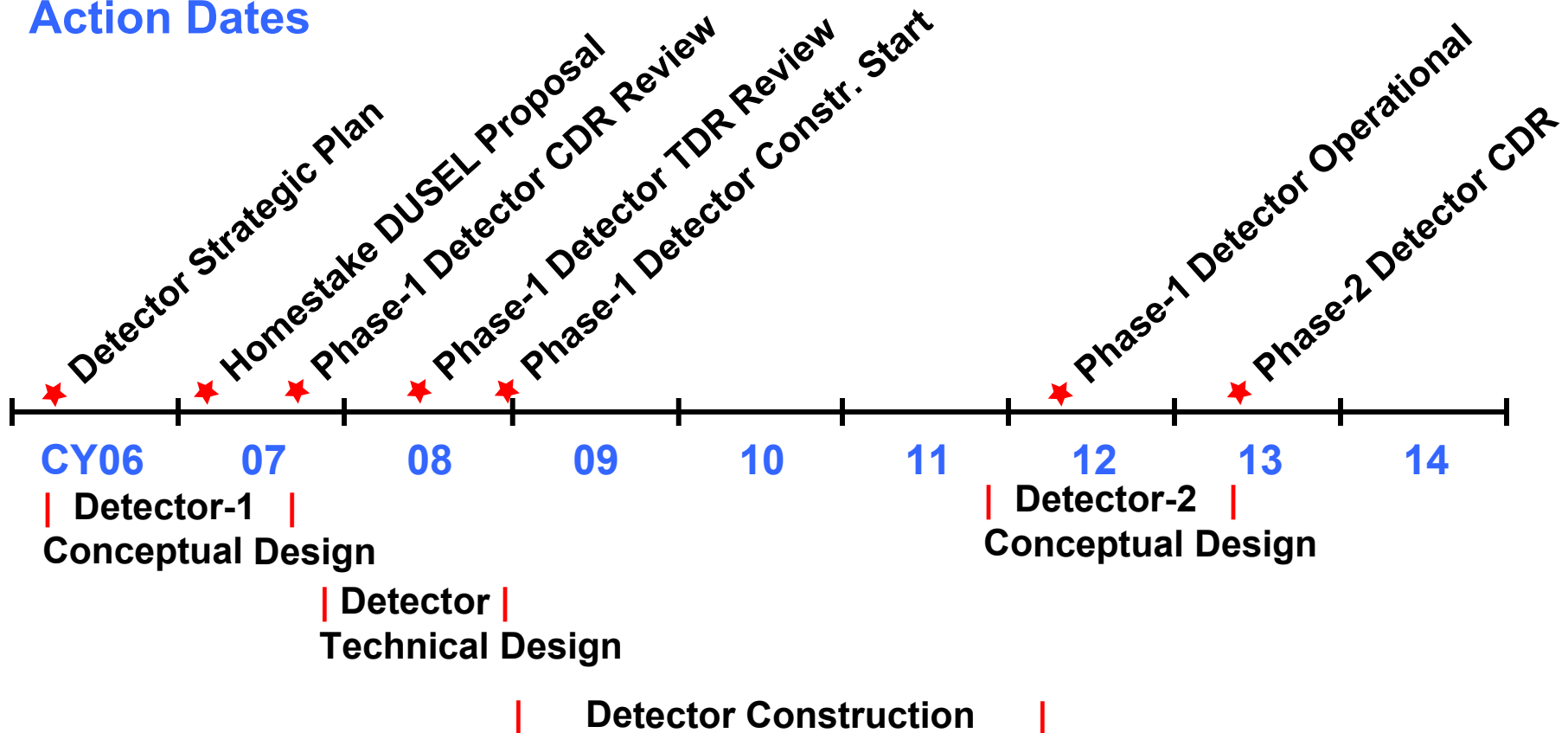
- create formal **Strategic Plan** documents for the ν beam and detector(s)
- begin work on **Conceptual Design Reports** for ν beam and detector
(a lot of this work is already complete but it needs to be consolidated in a comprehensive and readable report)
- solicit NSF/DOE R&D support for initiation of **Technical Design Reports** for the ν beam and detector (the technical report needs extensive engineering and project management support, hence significant development funding from the agencies)

Agree upon a schedule and organization basis for doing these documents

- today is not too soon for agreeing on the Strategic Plan and its schedule
- the plan and schedule shown next is optimistic but not unbelievable...

Homestake VLBNO Program Timeline

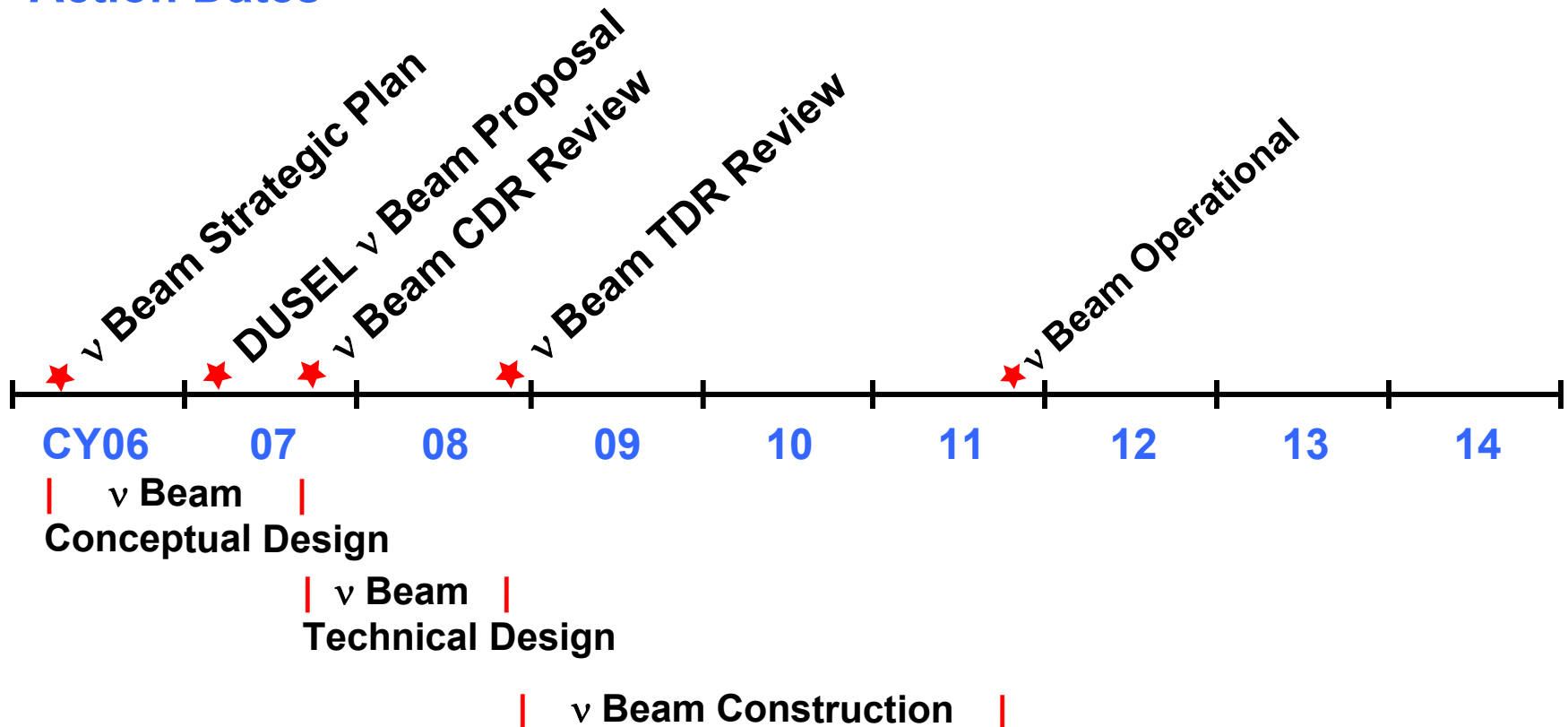
Action Dates



Activities

ν Beam Accelerator Program Timeline

Action Dates



Activities

Conclusions / Action Items

- Neutrino Oscillation parameters can be completely determined within the next two decades
- The most effective method is the **VLBNO + Wideband Super Beam**
- A Megaton-class Water Cerenkov Detector can do this experiment (perhaps built in modules and staged)
- Either BNL or Fermilab could be the source of an effective ν beam
- Combining VLBNO with the **Nucleon Decay Search** in the **NSF DUSEL** yields the best science and the most cost effective plan for the U.S.
- The next steps to pursue for realizing the VLBNO in DUSEL are:
 - create formal **Strategic Plan** documents for the ν beam and detector(s)
 - begin work on **Conceptual Design Reports** for ν beam and detector
 - solicit NSF/DOE R&D support for initiation of **Technical Design Reports** for the ν beam and detector